The Meteorological Service

Annual Report 1988-1989

Department of
Tourism and Transport

The Meteorological Service

Annual Report
1988-1989

The Meteorological Service,
Glasnevin Hill,
Dublin 9

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FOREWORD

The period 1988-89 was marked by some significant changes in the Meteorological Service, not least the reduction in staffing levels by some 12%. The early retirement scheme introduced into the Public Service in 1988, combined with normal retirement and resignation, resulted in an outflow of 34 people leaving a total of 253 at the end of the period. It is gratifying to note that the resilience of the Service and the cooperation of staff ensured that the level of service provided to our users was maintained. Some rationalisation measures were necessary, principally the centralisation of all aviation forecasting in Shannon Airport from March 1989. Shannon thus became the Service's Central Aviation Office, meeting all requirements for aviation weather forecasts and consultation within the state.

An innovation of general interest was the introduction of a new style television weather presentation on RTE in October 1988. The use of computer graphics makes for an attractive, modern presentation considerably superior to the old static style. Public reaction has been very favourable.

Another interesting development was our decision to participate in the HIRLAM project for the development of a short-range numerical weather prediction model. Pioneered by the Nordic countries, joined later by the Netherlands, the HIRLAM project offers a wonderful opportunity to Ireland to assist in the development of a state of the art weather forecast model. Research staff from our Service are already making a valuable contribution to the project.

1988 marked the retirement of Donal Linehan as Director of the Meteorological Service. His tenure as Director coincided with a period of general cutbacks in the Civil Service. The ability of the Service to sustain its range of services to the public and to its specialist customers, and indeed to take on new challenges, is a tribute to his wise and able leadership.

The considerable pressures on the administrative arm of the Service necessitated the combining of two years in this Report. As is usual a special topic is included, this time on European involvement in meteorological satellites.

D. Murphy
Director

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The Meteorological Service

FUNCTIONS

(1) The collection, analysis and publication of meteorological, geophysical and geochemical data;

(2) Research in fundamental and applied meteorology;

(3) The supply of weather forecasts, statistical information and scientific advice on meteorological matters to agricultural, industrial and public utility undertakings, the press, radio and television, maritime interests, and the general public;

(4) The supply of similar information to Government Departments, Semi-State Bodies and the Defence Forces;

(5) The provision of meteorological facilities for civil airlines and general aviation interests operating to and from airports in Ireland and/or flying over Irish territory, and the supply of general advice on the meteorological aspects of civil aviation.

(6) Cooperation with the Meteorological Services of other countries on matters related to meteorology and the representation of Ireland at international conferences.

INTRODUCTION

The Meteorological Service produces weather forecasts and climatological information for the general public and for a wide range of specialised interests - aviation, agriculture, marine, industry, commerce, sports etc. In addition, the Service plays a major role in environmental and geophysical monitoring; it acts as National Coordinator of the European Monitoring and Evaluation Programme and is responsible for a comprehensive programme of geomagnetic and seismological observations at Valentia Observatory, Co. Kerry.

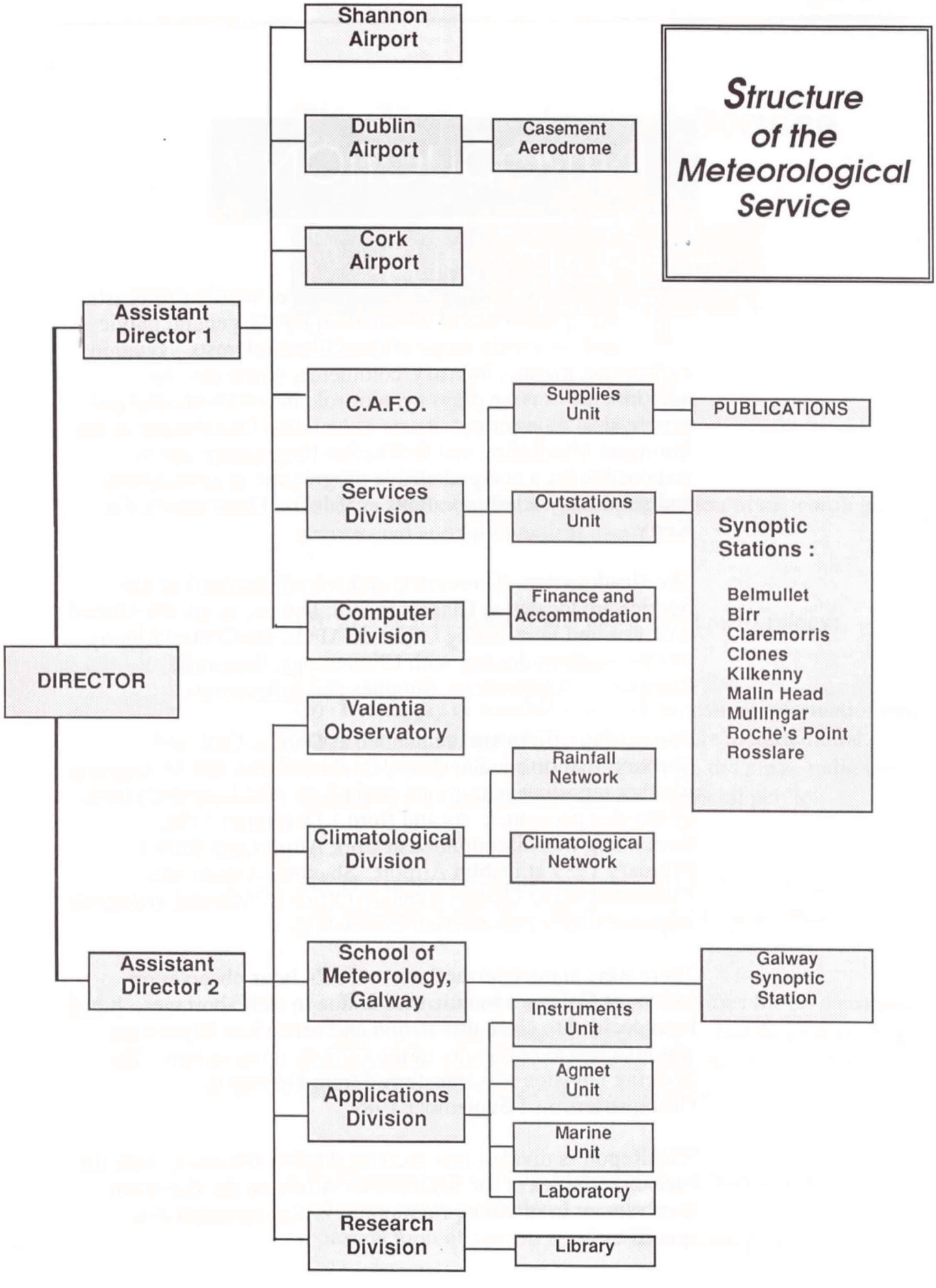
The Headquarters (Directorate and Administration) of the Service are located at Glasnevin Hill, Dublin, as are the Central Analysis and Forecasting Office (CAFO), the Central Library and the sections dealing with Climatology, Research, Computers, Applications, Supplies and Instruments.

Forecasting offices are maintained at Dublin, Cork and Shannon Airports and at Casement Aerodrome and 15 synoptic weather reporting stations are staffed on a 24-hour daily basis by Service personnel. As and from 1 December 1988, forecasting was discontinued at Cork Airport and from 1 February 1989 at Dublin Airport. Shannon Airport was designated as the Central Aviation Office (CAO) and undertook responsibility for all aviation forecasting.

There were some interruptions to the 24 hour observation routine at Galway synoptic station due to staff shortages. It had been decided to close this station and hence less importance was attached to continuity of the Galway observations. The Training Division was transferred from Galway to Headquarters on 1 September 1989.

This Report is divided into sections dealing separately with the various activities of the Service; an article on the European involvement in satellite programmes is also included as a special topic.

Structure of the Meteorological Service



OBSERVING PROGRAMME

A basic requisite for the effective functioning of a Meteorological Service is the regular supply of reliable, accurate observations of the various meteorological elements at the earth's surface and at different levels in the atmosphere. In addition to serving as an essential input to the preparation of weather forecasts, weather observations form the basis of information and advice on the planning of weather-dependent projects and on environmental protection.

In Ireland, surface weather observations are provided from three reporting networks - synoptic, climatological and rainfall; upper air observations are made at one station, Valentia Observatory, Cahirciveen. These observations are supplemented by weather reports from aircraft, ships, lighthouses and drifting buoys and by satellite and radar imagery.

Apart from providing weather reports, some synoptic stations are also involved in other observing programmes such as the monitoring of air pollution, atmospheric chemistry, solar radiation, phenology, magnetics and seismic activity.

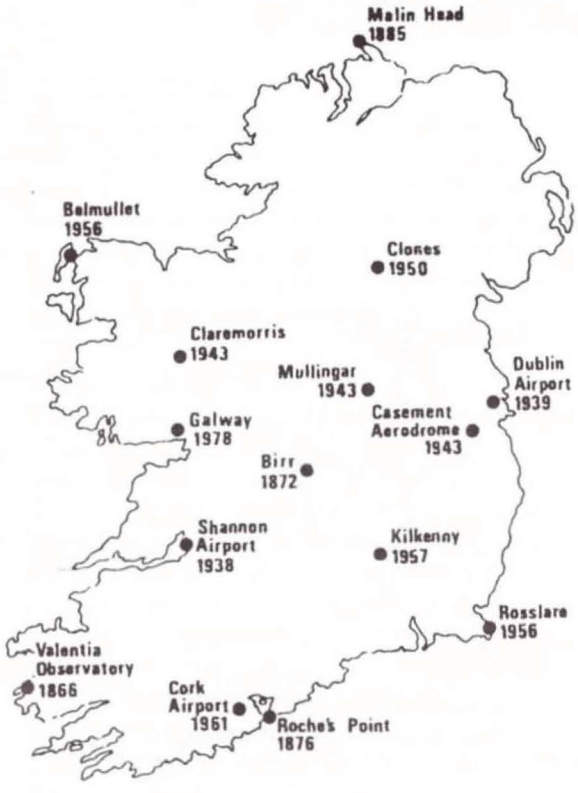


Figure 1 Synoptic Network

SURFACE WEATHER OBSERVATIONS

Synoptic Stations

The network of 15 Synoptic Weather Stations continued unchanged throughout 1988-1989. The locations and dates of establishment of these stations are shown in Figure 1. Due to staff shortages and financial restrictions affecting the payment of overtime, there was some discontinuity in observations. This affected Galway more than other stations.

Climatological Stations

At the end of 1988 there were 89 Climatological Stations in operation; six new stations were opened while two were closed. At the end of 1989 there were 88 Climatological Stations in operation; three new stations were opened while four were closed. The locations of Climatological Stations as of 31 December 1989 are shown in Figure 2.

Rainfall Stations

656 Rainfall Stations were in operation at the end of 1988 and 651 were in operation at the end of 1989. Sixteen new stations were opened in 1988 while thirty one were closed. In 1989 six new stations were opened while eleven were closed.

MARINE OBSERVATIONS

The Coastal Radio Stations at Valentia and Malin Head continued to relay ships weather reports to the Central Analysis and Forecast Office (CAFO) in Dublin for local use and for international distribution. Additional reports were received in real time from Irish ships mostly via British Coastal Radio Stations. Seven Voluntary Observing Ships, mainly car ferries, equipped by the

Locations of **Synoptic** and Climatological weather stations

figure 2

Meteorological Service made weather observations during the period. Port Meteorological Officers of the Service paid inspection visits to ships in Dublin, Cork and Rosslare. Meteorological equipment on board was checked and replaced where necessary during these visits. It is a matter of concern that the number of local weather reports from Irish ships continues to decrease. Visual observations of wind, weather and waves were made six times daily at five lighthouses operated by the Commissioners of Irish Lights - Kish Light, Wicklow Head, Fastnet Rock, Loop Head and Tory Island - locations are shown on Figure 3. In July 1989, Mizen Head commenced operations when the Fastnet Rock was automated.

Hourly weather reports continued to be received in CAFO from the automatic weather stations on the Marathon Platform in the Kinsale Gas Field; availability of wind reports was 98.9% in 1988 and 92.6% in 1989. The Baylor Wavestaff on a leg of the platform was put out of action by a storm early in February 1988 and did not return to service until early September that year. Availability of wave reports was 48.3% in 1988 and 87.4% in 1989.

Wave height measurements from a Waverider Buoy, moored outside the bar of the River Shannon, were transmitted twice daily by the Loop Head lighthouse to CAFO. Availability was 98.6% in 1988 and only 14.8% in 1989 as these reports ceased on 24th February 1989. Routine measurements of sea temperature at Malin Head continued on a twice daily basis.

UPPER AIR OBSERVATIONS

Radio Sonde

The routine procedure of 2 ascents per day, at 1200 and 2400 GMT was maintained at Valentia Observatory. Repeat ascents were necessary on 22 occasions in 1988 and 15 occasions in 1989 due to failure to reach the minimum acceptable height (200 hPa) because of instrument failure or early balloon burst. The DigiCORA upper-air system was used on occasions for test purposes or when other ground equipment was out of order.

Radar Wind

The routine procedure of 3 ascents per day at 1200, 1800 and 2400 GMT was maintained. There were 25 occasions in 1988 and 2 occasions in 1989 when ascents were not possible due to ground equipment being under repair and cloud conditions were unsuitable for theodolite ascents.

Research Project

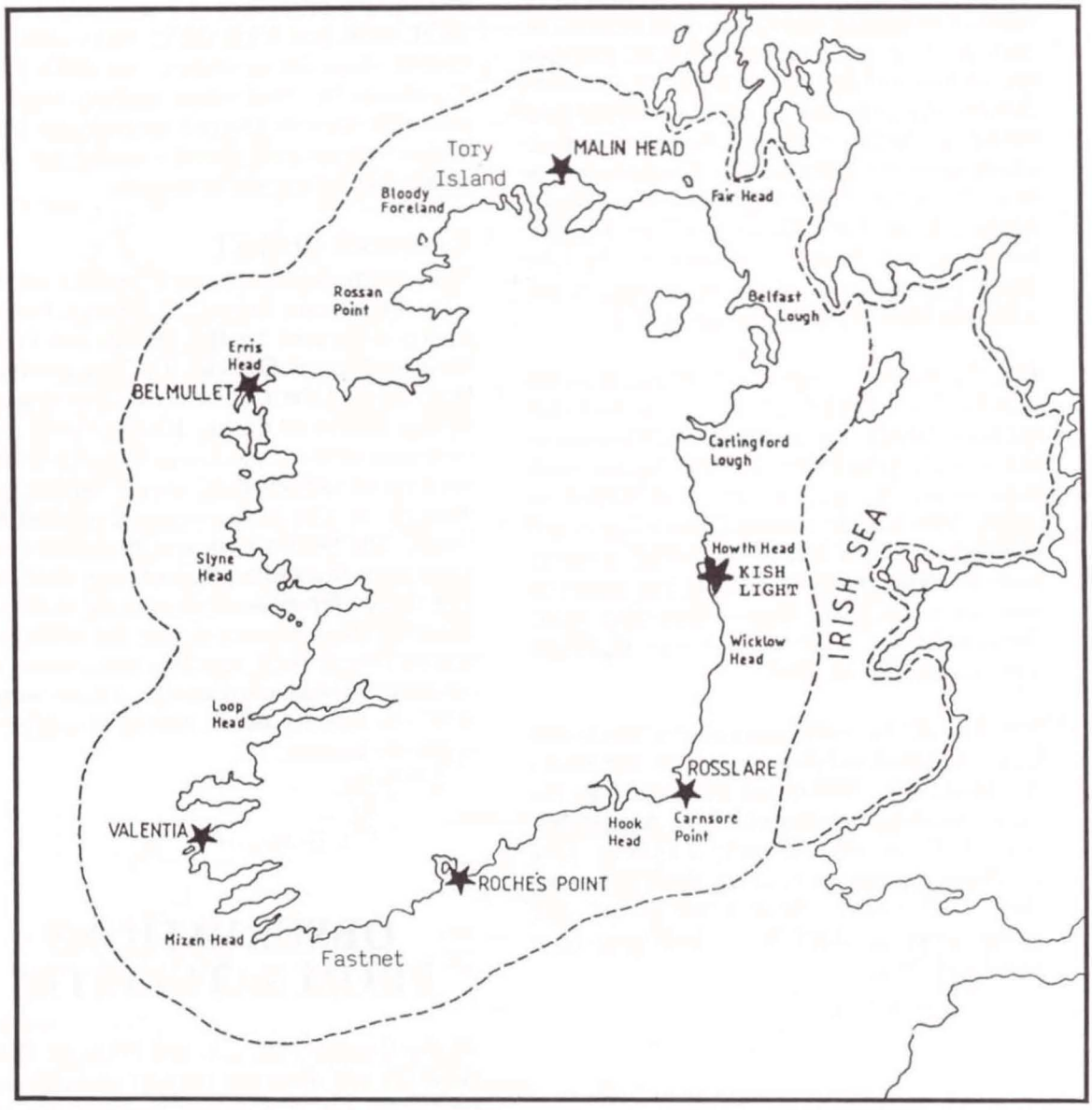
The international research project entitled "The Mesoscale Frontal Dynamics Project" jointly organised by the British and French Meteorological Offices, the University of Hanover and the U.K. Universities Research Group continued during January 1988. The objective of the project was to make detailed studies of active cold fronts which pass through the area to the west and northwest of Brest. The Observatory was requested to co-operate in the project by making additional full upper-air soundings during Intensive Observational Periods (when the passage of active fronts with suitable movement and orientation was indicated). There were 3 IOP's in January necessitating 11 additional upper-air ascents.

OBSERVATIONS FROM SATELLITES

At the Central Analysis and Forecast Office (CAFO) and Shannon Airport pictures were received on a regular basis from the METEOSAT geostationary satellite and from the American NOAA polar orbiting satellites. Satellite images were relayed from CAFO to Dublin Airport and to Casement Aerodrome while those received in Shannon were relayed to Cork Airport. Pictures were also relayed to RTE for use in the live television forecasts. A Technavia satellite display system was installed at CAFO in January 1988 and at Shannon Airport in December of that year.

figure 3.

Marine Weather Reports and Forecasts



★ Reports included in some sea area forecasts

---------- Bounding of area covered in sea area forecasts

WEATHER SURVEILLANCE RADAR (WSR)

The Shannon Digitised Radar System operated satisfactorily during the period. Digitised prictures continued to be received in Shannon and CAFO and were also transmitted to the British Meteorological Office. The Selenia WSR at Dublin Airport also operated satisfactorily. However, because of its age - over 25 years in operation, - specifications were prepared for a replacement. Tenders were invited with a view to placing an order in 1990 for the purchase of the new system.

Digitised radar data from Castor Bay in Northern Ireland were made available to the Service in 1988 with data displayed on a BBC microcomputer. Work commenced on providing software for displaying digitised weather radar data on a network of IBM compatible personal computers. The first of these was installed in CAFO in 1989 replacing the BBC microcomputer and the picture quality was very good.

GEOPHYSICAL OBSERVATIONS

Apart from being a synoptic and upper-air weather station, Valentia Observatory, Cahirciveen also acts as the country's main geophysical observatory at which geomagnetic and seismic variations are monitored.

Geomagnetism

No changes were made in the absolute observing procedure. During 1988 an EDA FM 100B triaxial fluxgate magnetometer, a Campbell Scientific CR1O data logger and a PROMPT IBM compatible computer were obtained. The magnetometer was installed in the variometer hut and the sensor outputs for the three components H D and Z were recorded and stored. This system was under test in 1988 and became the official instrument from 1st January 1989, the La Cour Variometers being retained as a back-up. Data are now transmitted to the World Digital Data Centre on magnetic disk. Hourly values of Declination, Horizontal Force and Vertical Force for the years 1971 to 1988 were transferred to magnetic disk and forwarded to the WDDC. 'Magnetic Observations at Valentia Observatory' for the years 1986-1988 were published.

Seismology

Continuous recordings of N/S E/W and Vertical long-period and Vertical short-period components of seismic activity were maintained using the WWSSN short and long-period instruments.

SOLAR RADIATION MEASUREMENTS.

The Solar Radiation Programme of the Service continued without any major changes. The Volz Sun Photometer turbidity measurements were discontinued in 1989 as readings were considered unreliable and plans were prepared for the purchase of a replacement photometer. Angstrom's turbidity coefficient B was computed using a Linke-Feussner Actinometer fitted with OG1 RG2 and RG8 filters. Radiation data for all stations were input on microcomputer at Valentia Observatory. They were quality controlled and final data transferred to Dublin HQ via IBM PC floppy discs.

The Solar Radiation Observations yearbook was published for 1986, 1987 and 1988. Daily totals of Global Solar Radiation as well as hourly values of radiation balance were supplied to the Voeikov Geophysical Observatory, Leningrad for inclusion in the W.M.O. World Network Publication.

ATMOSPHERIC MONITORING

The Meteorological Service continued to participate during the period in the World Meteorological Organizations (WMO) Background Air Pollution Monitoring Programme, the European Air Chemistry

Network (EACN) and the European Monitoring and Evaluation Programme (EMEP). Air and precipitation samples were collected and analysed for certain chemical constituents (outlined in the 1987 annual report). Daily pH testing for acidity in precipitation, which began in Rosslare in May 1987, was extended to Mullingar, Casement Aerodrome and Claremorris in 1988. In addition, sampling and analysis of daily air samples for their nitrogen dioxide content began at Valentia Observatory in October 1988.

Atmospheric Chemistry

Chemical analysis tests were carried out on more than 1500 samples of air and precipitation annually. There was an overall decrease in acidity in precipitation samples for the period compared to 1987 with less than one third of the samples tested having a pH value of less than 5.5 The most acidic pH values occurred in daily precipitation samples - 3.57 at Rosslare in December 1988, 3.82 at Claremorris in May 1988 and 3.89 at Rosslare in July 1989. The median pH value for monthly precipitation samples was 5.9 in 1988 and 6.0 in 1989.

Monthly mean values of sulphur dioxide (SO_2 -S) in air samples collected at Valentia Observatory in 1988 ranged from 0.2 to 1.0 and in 1989 from 0.2 to 1.8 micrograms per cubic metre. Nitrogen dioxide (NO_2-N) samples in air were collected at the same location from October 1988 to December 1989. The monthly mean values varied from 0.2 to 2.5 micrograms per cubic metre. The highest daily maximum concentration for sulphur dioxide was 5.7 micrograms per cubic metre and for nitrogen dioxide it was 8.2 micrograms per cubic metre.

Interlaboratory calibration tests were carried out with satisfactory results, on test samples provided by WMO and the EMEP each year. Equipment for participation in an EMEP intercalibration exercise for samples and sampling methods was sent to Sweden in December 1989.

Radioactivity

The following samples were collected and processed for subsequent radioactivity measurement by the Nuclear Energy Board (NEB).

- Airborne dust collected on filters at Dublin HQ (5 days weekly) and Valentia Observatory (daily).
- Weekly total fallout and tap water samples for Dublin HQ and Valentia.
- Monthly precipitation samples for Belmullet, Dublin Airport, Mullingar, Roches Point, Rosslare and Valentia Observatory.

All the samples were measured by the NEB for gross beta activity. High resolution gamma spectroscopy was also performed on the precipitatin samples.

External Gamma Doserate Monitors were installed by the NEB at Casement Aerodrome, Rosslare, Cork Airport, Valentia Observatory, Shannon Airport, Birr, Clones and Malin Head during the period.

FORECASTING SERVICES

GENERAL FORECASTS

Newspaper Forecasts

A comprehensive service of forecast texts and in some cases forecast maps was supplied to daily, evening, weekly and Sunday newspapers. Holiday resort reports and forecasts were supplied for some of the Sunday newspapers.

Radio Forecasts

With some minor changes in scope and timing, forecasts supplied to national and local radio stations, to AMCS Coastal Radio Stations and MRCC Shannon followed the same schedule as in 1987.

Television Forecasts

Weather forecast presentation by Service meteorologists on RTE 1 (TV) continued each day after the main evening news until 2 October 1988. A new presentation format commenced on 3 October involving a staff Meteorologist, based in the Television Centre, presenting a series of TV Weather Forecasts throughout the day on both RTE 1 and Network 2. A new graphic presentation had been introduced on 15 February 1988.

The weekday interview presentation on the "Live at Three" programme continued from January to Easter 1988 and, commencing in the autumn of that year, it became part of the new T.V. presentation.

Telephone Forecasts

The system of recorded weather forecasts (ATWS) continued to be used extensively during both years. Totals of 2.00 and 2.14 million calls were made on the system in 1988 and 1989 respectively; the 1987 figure was 1.77 million calls (see Figure 4).

AVIATION FORECASTS

There was an overall increase in the demand for meteorological services to civil aviation in 1988 and a slight reduction or levelling off in 1989. There was a significant increase of 57% during 1989 in the number of briefings for training flights at Shannon Airport over the 1988 figure. Special forecasts were provided both years for the Hot-Air Ballooning Championships. Local warnings of hazardous weather conditions at airports were issued as necessary and the Shannon Airport office issued 352 (1988) and 433 (1989) warnings of hazardous weather conditions for aviation in the Shannon Flight Information Region.

Central Aviation Office

The Central Aviation Office was established at Shannon Airport on 1 February 1989 and the meteorological office at Shannon Airport thus became responsible for all aviation forecasting in the State, both civil and military. This resulted in an increased output of forecast material for aviation purposes. Routine issue of Terminal Area Forecasts commenced for Dublin, Cork, Casement and Gormanston. Issue of Local Area Forecasts for the provincial airports Connaught, Sligo, Carnmore, Farranfore, Waterford and Carrickfin also commenced on a regular basis.

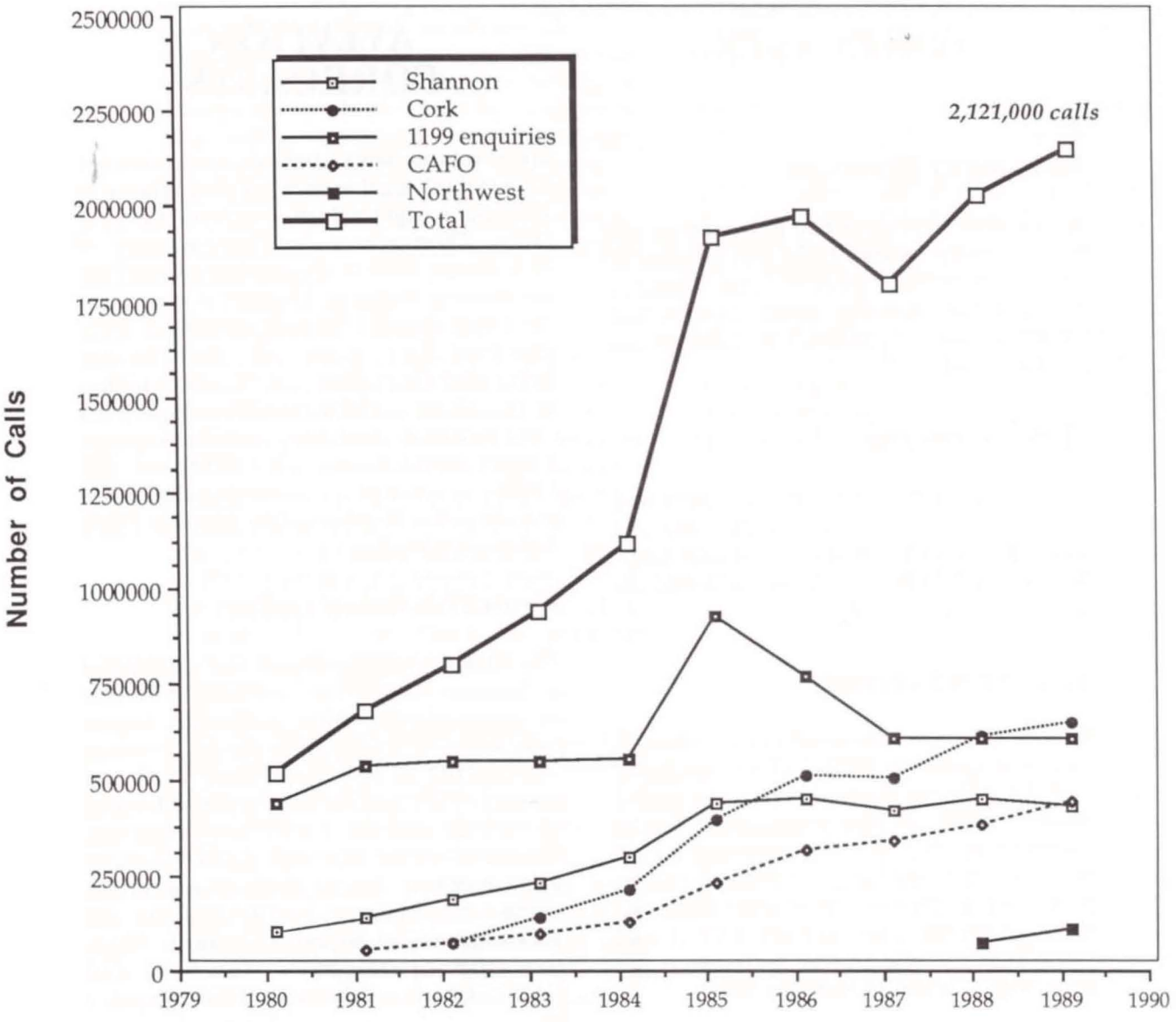
Air Corps

Documentation and briefings were provided for Air Corps pilots operating fixed wing and helicopter aircraft in training, search-and-rescue and ambulance missions, national security and Army/Garda operations, sea-fishing protection and the transport of Government Ministers and officials.

In addition to local briefings at Casement Aerodrome, information was supplied on a regular basis to Air Corps pilots based at other locations throughout the country.

figure 4

Automatic Telephone Weather Forecasts 1980 to 1989



ATWS Numbers :

Leinster, Cavan, Monaghan : (01) 425555

Dublin area : 1199

North Munster, South Connaught : (061) 62677

South Munster : (021) 964600

North Connaught, Donegal : (071) 69111

Courses in meteorology were provided to Air Corps Officers and Air Traffic Controllers at Casement Aerodrome. A two week course in Basic Aviation Meteorology was held at the Aerodrome for Naval Cadets.

The Aer Rianta/Irish Aviation Council 'Air Display Spectaculars' were held at Casement Aerodrome on 14 August 1988 and 13 August 1989. A forecasting service was provided at the request of the organisers on both dates and on the immediately preceding dates to facilitate arriving participants and rehearsals.

FORECASTS FOR AGRICULTURE

The farming community is one of the largest groups requiring weather forecasts. The ATWS provides much of the required information but, on occasions, more detailed forecasts are useful for specific agricultural purposes.

Special weekly forecasts for farmers were supplied to some farming and national daily newspapers. A weekly interview type forecast was broadcast on RTE Radio 1 during 1988 but was discontinued in May 1989 when this farming programme was changed to an early morning slot and was pre-recorded. A weekly farming forecast, broadcast on RTE 1 television each Sunday, commenced in 1988 and became firmly established in 1989.

Daily forecasts (updated 3 times each day), a 5-day outlook (updated once daily) and a range of agristatistiçs (updated weekly) were provided for the Agricultural Videotex Project (Agriline).

A fire warning service was provided to the Forest and Wildlife Service in 1988 but, following the reorganisation of the forestry services (now named Coillte) no fire warning service was requested in 1989. Warnings of weather conditions favourable to the spread of potato blight and special frost warnings for fruit growing areas were added to radio and television forecasts when appropriate. There were 6 potato-blight warnings in 1988 and 3 in 1989.

Weekly forecasts were supplied to An Foras Taluntais (The Agricultural Institute) in connection with a grass production experiment, to An Comhairle Oiliuna Talamhaoiochta (The Agricultural Advisory Service) and to Teagasc (Agriculture and Food Development Authority) which replaced AFT and ACOT during 1988.

MARINE FORECASTS

Coastal station reports and sea area forecasts were included 4 times daily in the weather forecasts broadcast on radio from CAFO. Other forecasts specially tailored for marine interests were also provided to trawler skippers, Irish Lights survey vessels etc.

Gale warnings were issued for Irish Coastal waters and for the Irish Sea. Forecasts for Dublin Bay were prepared for the ATWS. Commercial fishery concerns, State and local authorities engaged in harbour and coastal projects, oil and gas exploration companies, yacht clubs and organisers of aquatic events were all supplied with special forecasts.

FORECASTS FOR INDUSTRY

Special forecasts were supplied on request to commercial firms and to public utilities such as the Electricity Supply Board, Dublin Gas and Coras Iompair Eireann (The Irish Transport Company). Warnings of severe weather conditions were issued to local authorities, the Defence Forces, the Office of Public Works and to a number of commercial concerns.

CLIMATOLOGY

The Climatological Division of the Meteorological Service is responsible for the supervision of climatological stations, the collection, quality control and archiving of their data, and the processing of climatological data into forms suitable for use by other branches of the Meteorological Service and by outside agencies. These processed data are used in the preparation of climatological publications, the investigation of particular aspects of the Irish climate and in dealing with requests for climatological information.

Climatological Network

Rainfall and climatological stations were inspected during 1988 and a list was prepared of stations which it was proposed to close in 1989. However, due to staff shortages in 1989 it was not possible to organise systematic visits and only a few stations were closed.

Publications

The Monthly Weather Report Part I for the months January 1987 to August 1988 was published while the volumes for September to December 1988 were prepared for publication. Part I annual reports for 1986 and 1987 were published. Part III (Synoptic Stations) was amalgamated with Part I since January 1987. The annual Part II report for 1987 (monthly rainfall values for some 700 stations) was published during 1988.

The Monthly Weather Bulletin was issued each month and was expanded from an eight to ten page format in July and September 1988 and December 1989 to permit more detailed coverage of special topics.

Special Reports

Special reports were prepared on the storm force winds over Ireland on 9 February 1988, on snowfall in Ireland and on the heavy rainfall in parts of Munster on 10/11 October 1988. An internal note on 'Climate Change in Ireland' was prepared in November 1989 as was a note on 'Heavy Rainfall in the west and southwest of Ireland 27/28 October 1989. An article on 'Single Station and Regional Analysis of Daily Rainfall Extremes' was published in the December 1989 issue of the Journal of Stochastic Hydrology and Hydraulics.

Enquiries

The Climatological Enquiries Office dealt with 6,012 requests for climatological information in 1988 and 4250 enquiries in 1989. Fees were charged for 792 of the 1988 enquiries and for 746 in 1989. Attendances by meteorologists as expert witnesses in court were required on 29 occasions in 1988 and on 40 occasions in 1989.

RESEARCH

The Meteorological Service has been running a Numerical Weather Prediction system operationally since June, 1980. Since then, the system has undergone considerable development and many enhancements have been made. Our main research activities have been in devising efficient and accurate numerical techniques for integrating the equations of motion. Activities during 1988 are reviewed below. The Numerical Weather Prediction system operational as of 31st December, 1988 is summarised in Table 1.

We have continued refining and enhancing our operational Numerical Weather Prediction suite. The cut-off times for the operational forecast runs, based on midnight and midday observations, are one hour and 50 minutes after observation time, and the 36 hour forecasts are ready by 2.30 and 14.30 respectively. They thus provide the forecasters with the most timely objective guidance based on these data.

The Automatic Data Extraction system has been recoded to run on the VAX 11/780 communications computers. Comprehensive documentation of the new system is in preparation. A number of improvements have been made to the Objective Analysis routines. Thicknesses retrieved from satellite radiance measurements (SATEM) are now used in the analysis of the mass field. A study of the impact of these observations on the analysis has been carried out. The analysis has been extended to include humidity. Experimental analyses using a fine mesh (50km) have been undertaken.

The forecasting model has been adapted to include large scale moist processes. Operational testing of this version must wait until the VAX computers are available. The semi-Lagrangean integration method has been extended to the integration of the shallow water equations on the sphere. A copy of our forecasting model on magnetic tape has been sent to the Meteorological Authority in Cairo, Egypt, at their request.

The slow equations have been used to develop a baroclinic model, LASER. This model has been used successfully to initialize the data for our forecast model.

An algorithm for calculating the isentropic potential voricity has been coded up. This parameter is useful as an indicator of frontal position and intensity. Operational testing awaits implementation of the VAX machines.

A trajectory model has been developed and is currently used in a number of applications (air pollution studies, nuclear fall-out exercises, etc.). The latest version of the model includes a limited description of dispersion processes. A global version of the trajectory model was installed at ECMWF during the year.

Numerous enhancements to the Graphics Package have been made. The system has been implemented on the VAX computers. Special programs have been written to provide the forecasters at RTE with charts output on graphics VDUs and laser printers. Support has been given to the Computer Division in selecting and evaluating new pen-plotters. New graphics terminals and digitisers have been installed. Several new graphical output products have been developed to provide guidance to the forecasters at the CAO in Shannon Airport. The programs which prepare data for the Aer Lingus flight planning system have been modified and extended for the VAX computers.

HIRLAM

The main feature of 1989 occurred in April when Ireland became a member of the HIRLAM (High Resolution Limited Area Modelling) Group Project. Work on this project dominated research activities during 1989. The goal of the effort is the production of a fine mesh model with sophisticated physics, capable of providing detailed and accurate short range forecasts. This model will form the kernal of our future operational numerical prediction system.

In cooperation with the other HIRLAM participants, we are undertaking work on several aspects of the model. In particular, a two time level semi-Lagrangian formulation of the advection is being developed. By the end of 1989, this scheme has been successfully incorporated into a dry version of the HIRLAM model, and is performing

satisfactorily. We have also carried out investigations into the use of filtering integration techniques, and of stretched coordinate systems. Plotting programs have been developed to display output data from HIRLAM runs.

NWP Research

Further work has been carried out in the development of semi Lagrangian schemes. An alternative formulation has been developed which is more accurate than the method currently used operationally. We have developed a limited area baroclinic model LASER based on the slow equations. This model has been tested as a means of initialization and the results have been satisfactory. An integration scheme based on the Laplace transform technique, which eliminates gravity wave noise, is under continuing investigation. An alternative scheme which uses the Z transform (the discrete analogue of the Laplace transform) is also being studied and a report is in preparation. The problem of partitioning the wind over a limited area into rotational and divergent components has been studied.

Work Related to the VAX Computers

Work continued on modification of the data decoding and quality control programs for the VAX machines. A report on the Automatic Extraction system has been prepared for internal distribution. The plotting programs (including the CHARTS program) were modified to run on the VAX. Various packing and unpacking routines were written to facilitate transfer of files between the VAX and the DEC-2050. Some special plotting programs were developed (on the VAX) to test the reception of the GRIB-code products obtained from ECMWF. Plot programs were modified to access the data-base of NWP products.

The analysis code was modified to run under Fortran-77. While making the conversion a number of small improvements were introduced. File formats for the observations were modified to make the analysis compatible with the new ADE running on the VAX. Experimental runs of the analysis on a fine grid were made, and changes were made to the data selection algorithm in connection with these experiments.

Graphics

The two Calcomp 960/925 plotters in CAFO were replaced by two Hewlett-Packard 7595A plotters. Two additional Hewlett-Packard plotters were installed in the Central Aviation Office in Shannon. New efficient driver programs were developed for these plotters (with versions running on both the DEC-2050 and the VAX-780) to enable them to be run in an on-line mode. The new software was ready for the opening of the CAO on 1st March and the plotters became operational in Shannon on this date.

Various plots were changed to accommodate the new plotters. A new inter-chart and a new tephigram sheet were developed using the new plotters. The entire graphics system was converted to Fortran-77 to make it more compatible with the VAX. Changes were made to the internal plot-file format to facilitate the use of the Hewlett-Packard on-line plotting system. The file format was changed from sequential to random access.

The ECMWF MAGICS plotting system was implemented (on the VAX) by writing our own version of GKS. The CHARTS program was modified to produce hardcopy on a laser printer rather than a dot matrix printer.

International Cooperation

The SHARE graphics/ade was installed in Argentina. The system was updated in Brazil. The graphics system was installed in Algeria (under the aegis of the UNDP/STAS program).

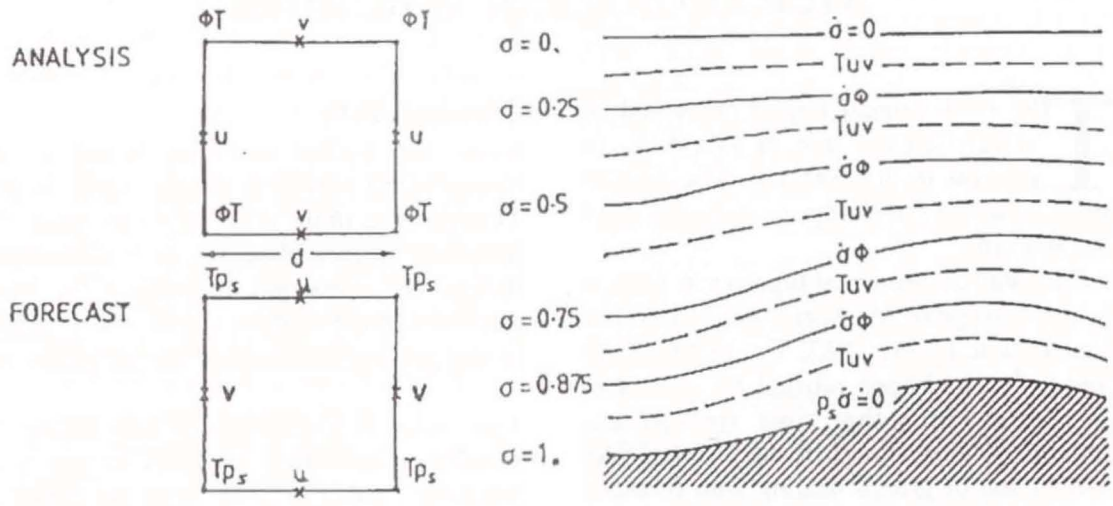
Miscellaneous

The verification suite continues to run and to accumulate statistics for monitoring our NWP system. Work is continuing on the investigation of smog in the Dublin area.

The Project Leader of HIRLAM, Nils Gustafsson, visited the Division on 27-30 September 1989 and significant progress was made during his stay.

Table 1

Numerical Analysis and forecasting System



Analysis

Method	3-D univariate optimal interpolation
Analysed variables	Sea-level pressure, geopotential, temperature, wind-components, humidity
Grid	Arakawa D-grid on polar-stereographic projection; d=150km at 60°N
Levels	1000, 850, 700, 500, 400, 300, 250 and 200mb
Observation Types	SYNOP, SHIP, BUOY, TEMP, PILOT, AIREP, ASDAR, SATOB, SATEM
First Guess	ECMWF 12 or 24 hour forecasts of geopotential and wind
Data Cycle	12 hours

Prediction

Formulation	Primitive equations
Independent Variables	λ,ϕ,σ,t
Dependent Variables	T,u,v,p_s
Diagnostic Variables	Φ,σ
Grid	Arakawa C-grid, transformed lat/long, d=1.0° , five levels in vertical
Integration Domain	Europe, North Atlantic, Eastern Canada
Finite Difference Scheme	Second order accuracy
Time integration	Advection : Semi-Lagrangian Adjustment : semi-implicit Timestep : Δt=90mins
Parameterization	Orography : Smooth Surface Friction (Ekman) Vertical Eddy momentum transport Horizontal diffusion : near boundaries Dry convective adjustment (applied every 90 mins) Moisture : not included Radiation : not included
Boundaries	Upwind difference scheme. Values from ECMWF forecasts updated every 6 hours.

SPECIAL TOPIC

Europe's Involvement with Meteorological Satellites

The 1981 Annual Report contained an article on the use of satellites in general in this Service. The present article concerns the European meteorological satellites only.

16 European States joined together in 1986 to form a European Meteorological Satellite Organisation, EUMETSAT. The EUMETSAT Convention had been ratified by Ireland in 1985, and since that time Ireland has participated in meetings of the EUMETSAT Council and of groups dealing with financial and other matters concerning the European meteorological satellite programme. European involvement in meteorological satellites before that time was through the European Space Agency (ESA). ESA designed and built (with some of the work contracted to private aerospace companies), launched and controlled the earlier series of Meteosat satellites. They also processed the images at the European Space Operations Centre (ESOC) in Darmstadt, West Germany. While a considerable amount of this work still remains with ESA working under contract for EUMETSAT, much of the planning work is done now by EUMETSAT.

ESOC

The Meteosat Exploitation Project at ESOC consists of various teams including engineers, software staff and satellite controllers, and a meteorological team. The MET team includes a number of theoretical meteorologists, other meteorological and administrative staff and a group of 6 shift working meteorologists. This group supervises the operational side of things (the Meteorological Information Extraction software, in general, is developed and maintained by meteorological personnel rather than by the computer section) and also does the manual quality control of the various products of the centre.

The Satellite

From the initial drawing board to an operational satellite takes many years. Though it is more than 10 years since the launch of the first Meteosat, the basic satellite design has remained unchanged - a spin-stabilised, three channel satellite - a tribute to the proven robustness of the initial design.

The series of geostationary meteorological satellites launched by ESA began with Meteosat 1 (M1) in 1977. After the failure of this satellite in 1979, M2 took over and was the 'operational' satellite until 1988. As this was running out of fuel, M3 was launched in 1988 to fill the gap before the launch of the first formally operational satellite. The naming of satellites sometimes causes confusion as names are often changed after a successful launch and commissioning. Presumably this is in order to keep the sequences of operational satellite names unbroken by unsuccessful launches or fatal malfunctions.

Each of the Meteosats has been in geosynchronous orbit. This means that they are over the equator and orbit the earth once per day - thus appearing stationary over one particular longitude. The standard longitude for the Meteosat is the Greenwich meridian. The satellite does, however, drift in both the N-S and the E-W directions.

Images are taken in three channels. The visible radiometer detects light in the visible wavelengths, creating an image of the same type as would be seen by a normal camera. The infra-red (IR) radiometer detects 'light' in the infra-red part of the spectrum. This means that the image effectively sees the temperature of the objects in its field of view. This offers at least two advantages over the visible images: the meteorologists will have their pictures by night as well as by day, and they will have a measure of the height of

the cloud tops (derived from their temperature). The third channel images are in the near-infra-red part of the spectrum and give an indication of the amount of water vapour in the upper troposphere.
Some of the series have carried small experimental packages totally unrelated to meteorological applications.

The present satellite is cylindrical in shape with solar cells around the outside. Its diameter is 2.1m, height 3.2m. It is spinning at a rate of 100 rpm with its axis perpendicular to the earth's equatorial plane. It weighs about 320 kg. This includes 39kg of fuel at the beginning of its operational life. Its power requirement is about 200W.
From the meteorological point of view, the radiometers and detectors are the most important part of the satellite. The primary mirror aperture is 400mm. As anyone who has used telephoto lenses on a camera will know, the longer the focal length of the lens, the higher the magnification. In cameras, complex mirror lenses are used for the longest focal lengths in order to keep the lens to a manageable size. Mirrors are used in the satellite for the same reason, but also to minimize the absorption of the IR light before it reaches the detectors. The use of mirrors in place of lenses, also ensures that light from all wavelengths will be focused on the same plane. The focal length of the system is around 3650mm.

The radiation is focused onto detector arrays. The radiometer is stepped through 0.14 milliradians every time the satellite completes a rotation. The earth subtends an angle of approximately 18 degrees at the satellite. This means that the earth is covered by 2500 scan lines in 25 minutes. This leads to the satellite resolution of 5km in the IR channels and 2.5km in the visible channels at the subsatellite point (ssp).
A full set of images (referred to as a 'slot') consisting of two full disk images in the visible channel, offset from each other by 2.5 kilometers, one in the IR and one in the water-vapour channel is transmitted each half hour. There are thus 48 slots per day.

Launch / Early Orbit / Commissioning

The satellites are launched from Kourou, French Guyana. Initially they enter a highly elliptical orbit with a perigee of a few hundred km and an apogee of around 36,000 km above the earth. Then comes the critical firing of the solid expendable apogee boost motor. This leaves the satellite in as near to a circular orbit as possible. The satellite is then slowed at or near its nominal longitude. There follows a period of some weeks of commissioning during which the various functions of the satellite are checked out and decontamination (to rid the satellite of some of the water vapour carried with it into space) is performed. The satellite is then ready for operational use.
The continuing need to decontaminate the satellite causes a loss of images for about 48 hours a couple of times per year.

Control/ Ranging

Changing gains, manoeuvring, performing the necessary actions when the satellite is in eclipse (receiving no power from the sun), decontamination procedures, sending the administration messages and keeping a constant watch on all the satellite subsystems is the job of the mission controller and the satellite controller. There are numerous other predictable and non-predictable events which require intervention from the ground. The eclipse period is one of the predictable events which has an effect on the product available to the users. Another example is the sun-satellite coincidence - at a few minutes past midday on the 3rd March and the 9th October each year, the sun, satellite and the ground station are aligned. An unpredictable though not unusual event is arcing between some of the components due to static buildup which can cause the loss of one or two slots.

Data transmission

The **Data Collection** mission is used to relay messages from balloons, buoys, ships, aircraft, automatic weather stations etc. This is useful for data collection platforms which are located in remote/ inhospitable locations. The satellite relays the messages from the

platform to ESOC, where the computer forwards them on landline/ telex etc. to the platform owner or in some cases they are retransmitted between Wefax (the analogue satellite pictures) messages to be received by modified Secondary Data User Stations (SDUS). The system is capable of handling up to 2000 messages per hour.

The **Meteorological Data Distribution** mission will relay alphanumeric (channel B) or graphical (channel A) meteorological information to anyone within the satellite field of view. The receiving equipment required is, again, broadly similar to an SDUS. It is intended that the information will be inserted by major meteorological centres (e.g. London/Rome).

Processing at ESOC

Raw image data are digital. They consist of a value of 0 to 256 for the radiance (i.e. brightness) of each point in the field of view. These data are received at the automatic Data Acquisition, Telecommand and Tracking station in the Odenwald hills just SE of Darmstadt. From there they are relayed to the computers at ESOC. They are separated into their 3 channels, timing signals added etc. all in real time.

Orbit perturbations, attitude and spin rate variations cause the actual image to deviate from the ideal image. Changes occur both within and between images. This is corrected at ESOC. In the final product at ESOC, the registration accuracy is better than 0.4 picture elements ('pixels') between two images taken an hour apart. Thus if we are looking at the same place on two images taken an hour apart, we can be confident that they are less than about 2 km apart.

Hi-res / Wefax dissemination

These rectified images go to users in two different ways: **Primary Data** users receive the full resolution data in digital form. These users include most national meteorological services and some other institutes. Anyone who wishes to do further processing of images should obviously be in this category. It is of course the more expensive option as a larger antenna, a demodulator and bit and frame synchronizers are required. Usually a dedicated minicomputer will be used also. Orbit parameters, black body and space counts, calibration coefficients and gains are included in the datastream. **Secondary Data** users include mainly airport meteorological offices, private users etc. The data are sometimes converted by users to digital form but can not be used in a quantitative way. SDUS form an excellent aid to forecasters, but a PDUS would be the normal choice for the integrated forecaster workstation concept which seems to be becoming more popular now. Images from the American GOES satellite are relayed from Lannion (France) and disseminated via Meteosat. Likewise, some fax charts are sent via ESOC and M4 from the Deutsche Wetterdienst in Offenbach.

Further Processing

For the purposes of Meteorological Information Extraction, the rectified image is segmented into about 5000 32*32 pixels. These segments form a useful base for scene identification and for statistical work. In practice the processing is usually confined to a great circle arc of 50 or 55 degrees from the ssp. Outside this area the atmospheric corrections become rather large. They thus deal normally with around 3500 segments. In the derivation of useful meteorological products from these data a variety of supplementary information is required. This includes non-meteorological information (geographical information, reflectivity tables, solar elevation/azimuth and spacecraft information) and meteorological information (including climatological data and / or approximate forecast data, sea surface temperature estimates, analysis and forecast charts for operator guidance in quality control and radiosonde data for comparative studies).

Radiation received by the satellite is characteristic of both the underlying surface and the intervening atmosphere. As most derived products will use the cloud or surface features, the atmospheric absorbtion effect must be compensated for. The aim is to produce an objective account of scenes within each segment. The output of this analysis is the class, mean radiance, standard deviation

and size of the various scenes. The method used is that of histogram interpretation.
One of the most difficult problems of scene interpretation is the identification of optically thin (semi-transparent) cloud. An empirical function is automatically applied at ESOC to minimize this problem.

Products derived at ESOC

1. Cloud motion winds.
Winds derived from the motion of clouds are considered by far the most important of the derived meteorological products. They are used by many National weather centres as input to the Numerical Weather Prediction schemes. Over 2500 winds (speed, direction and pressure) are derived per day, most of these in otherwise data-sparse areas. The winds are produced automatically from three successive infra-red images four times per day. The quality of these winds is continually being improved and there are plans to produce other sets of winds using the water vapour and possibly the visible channel.
2. An archive of the images in a compressed form (climate data set) is produced and is used by climatologists and other researchers.
3. A Precipitation Index is produced and is used mainly in the area of precipitation analyses in data sparse parts of Africa.
4 Certain parts of the field of view are written to tape in a special format to be used for intercomparison of satellite data.
5 The temperature of the histogram clusters identified as sea are obtained from the radiance corrected for atmospheric absorption. These sea surface temperature data are disseminated twice per day.
6. As the radiation measured by the WV channel comes predominantly from the water vapour in the upper troposphere, ESOC also has a scheme to produce a relative humidity product for the upper troposphere.
7. A cloud analysis is produced as a direct by-product of the segment processing.
8. Cloud Top Height is the only Meteosat product disseminated via the satellite. It consists of a graphical picture of corrected cloud heights divided into 4 height bands

This is just a brief overview of meteorological satellites from the perspective of the satellite operator. Many National Meteorological Services do further processing on the images. Bench forecasters around the world find satellite images most useful. The images are used by them, firstly to aid analysis of the current synoptic situation. With the paucity of conventional observations over the ocean, for example, Irish forecasters rely heavily on the satellite images to define the nature, location and extent of fronts. Secondly, the forecasters use the satellite images for now-casting (extremely short range forecasting) to predict onset of thunderstorms, to predict the time of arrival of rain at particular locations, to detect incipient rapid deepening of lows etc. Many other parameters of meteorological interest can be inferred from the pictures - large scale vertical motions or the smaller scale mountain waves for example.
Even though satellite projects are very expensive, they (and other remote sensing schemes) are seen as more cost effective than traditional forms of observation. Meteorological services around the world are working on new ways of assimilating satellite derived information into their numerical weather prediction schemes and new ways of incorporating the information into integrated meteorological workstations.
Likely future developments in the area of meteorological satellites include a second generation of improved Meteosats, European orbiting satellites with temperature and humidity sounding capabilities, and satellite-borne microwave sounders which will be able to see through clouds and give information on wave heights, surface pressures etc.
Forecasters eagerly look forward to these developments but the time has already arrived when a forecast office without the satellite images is almost inconceivable. Even the TV watching public would now feel let down if satellite images were to disappear from their screens.

COMPUTERS AND COMMUNICATIONS

The computer system of the Meteorological Service at its headquarters in Glasnevin continued to be based on a DEC-2050 mainframe computer (used for numerical weather prediction, graphics, climatological data processing, research projects and as a general-purpose computer) and two DEC PDP 11/40 microcomputers (used mainly for meteorological telecommunications).
Intensive software developed and testing continued in connection with the introduction of the Services' two DEC VAX 11/780 minicomputers in place of the ageing PDP 11/40 equipment. The second VAX 11/780 was installed in August 1988 to permit testing of the dual communications system and in October the DEC-2050 was connected to the two VAX machines by Ethernet to allow for data interchange via DECnet software between the three machines. The VAX system was used as backup for the PDP 11/40 system for some key operational systems since June. A standby airconditioning system was installed, also in June, to cater for the increased heat output in the computer room due to the introduction of the VAX equipment.

During 1989, Personal Computers were installed in Climate, Computer and Research Divisions and connected to an expanded Ethernet network so allowing easy exchange of data between the PC's, the DEC 2050 and the VAX 11/780's. The computer network was connected via a DECnet link to the European Centre for Medium-Range Weather Forecasts (ECMWF) in Reading, greatly facilitating the use of the Centre's computer system by IMS personnel.

New Computer Equipment

Among the additions to the computer hardward and software systems in 1988 were:
(a) Four Hewlett-Packard Draftmaster 7595A pen plotters from Hewlett-Packard Ireland Ltd in December. Two of the units were acquired to replace the ageing CalComp 960 plotters in use in the Central Analysis and Forecast Office in Glasnevin, and two for Shannon Airport meteorological office to provide automatic chart plotting for the envisaged Central Aviation Office at Shannon.

(b) The setting up of the weather office in RTE in October to cater for the revamped weather presentations necessitated the acquisition of some computer equipment, namely a DEC VT340 graphics terminal, a Canon LBP-8II laser printer and a DEC LA50 text printer, and the setting up of a communications link with the Glasnevin computer system.
(c) In order to implement the rationalised and upgraded communications links between Glasnevin and the airport offices at Dublin, Shannon, Cork and Casement Aerodrome, and also to supplement and replace equipment in Glasnevin, ten Canon LBP-8II laser printers, ten DEC LA75 matrix printers and twenty DEC VT320 visual display units were acquired and deployed in November.

(d) A software contract for the provision of VAX telex interface software was awarded to Baltimore Technologies Ltd, Dublin, in May. This was to allow for the automatic collection of hourly observations from meteorological stations and the interrogation of meteorological databanks by telex. In addition five DTI telex interface units were acquired from Telecom Eireann.

(e) To allow for further development of climatological data handling, equipment was acquired for the Climatological Division in the form of a DEC VT340 graphics terminal and a Prompt IBM - compatible PC. Various software packages associated with the WMO CLICOM project were also acquired for the PC.

(f) To facilitate the implementation of X.25 communications links to the British Meteorological Office at Bracknell and the European Centre for Medium-Range Weather Forecasts, Reading, VAX PSI software was purchased from Digital Equipment Ireland Ltd in June.

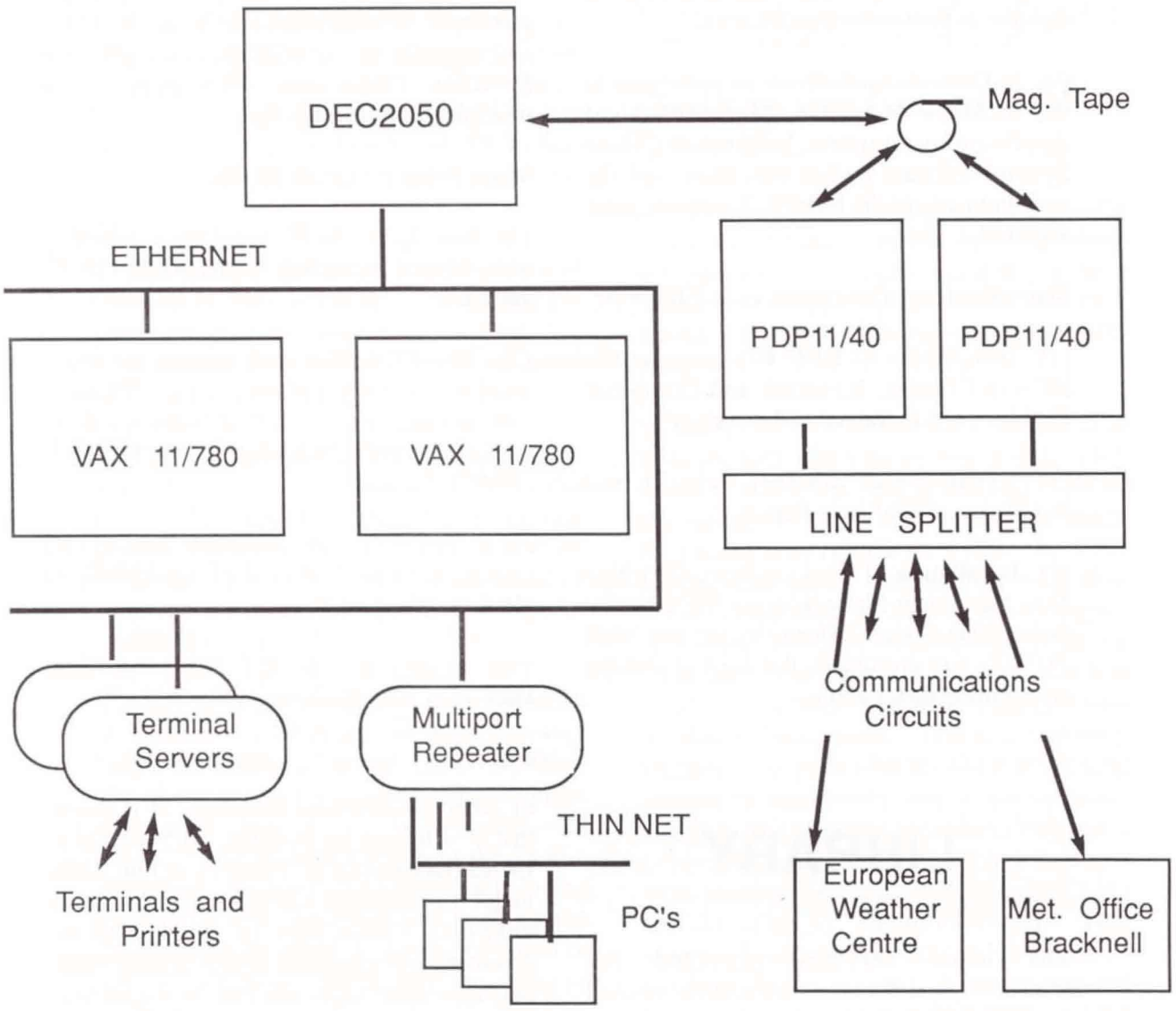
(g) A computer cabling system for the headquarters building was installed by Bootstrap Ireland Ltd. The new system

figure 5

IRISH METEOROLOGICAL SERVICE

COMPUTER CONFIGURATION

Date : 31-Dec-1989



Computer Systems :

The PDP 11/40 computers are used operationally for communications.

The DEC 20 is used for running Numerical Forecast Models and general purpose computing such as Climatological work and computer graphics.

The Vaxes are in the process of development for communications and general use and are also connected to the European Weather Centre and Met. Office, Bracknell.

rationalises the computer room cabling, provides patch panels for flexibility in making connections to the computers and replaces older cabling to terminal locations throughout the building with more modern cables, while at the same time allowing for increase in the terminal population.

(h) In December a decision to participate in the ECMWF MAGICS (Meteorological Applications Graphics Integrated Colour System) software project was taken, and the essential parts of the MAGICS software were acquired.

Major Hardware Developments in 1989 were

(1) Installation of DEC IBM-compatible PC's in Climate, Research and Computer Divisions and in Valentia Observatory.

(2) Expansion of Ethernet Network and installation of Multiport Repeater.

(3) Installation of Exabyte 8mm Cartridge Tape Subsystem for backing-up VAX 11/780 disks. This device is shared by the two VAX 11/780's and eliminates the need to change tapes during disk backup.

(4) Installation of dial-up link to Digital Equipment's RDC (Remote Diagnostic Centre) in Basingstoke, facilitating maintenance of VAX 11/780's.

(5) Installation of two HP-7959A pen plotters in Central Aviation Office, Shannon, and upgrade of the computer link between Shannon CAO and Glasnevin to a multiplexed 9600 baud line.

Major Software Developments

(1) New X.25 EMTN link from the British Met. Office Bracknell to the VAX 11/780 system.

(2) New DECnet-based connection from ECMWF to VAX 11/780 system. The new link operates at a speed of 9600 baud, in comparison with 2400 baud for the ECMWF - PDP 11/40 link.

(3) Software to connect low-speed communication lines (MOTNE,AFTN) to VAX 11/780 system.

The computer configuration on 31st December 1989 is shown in Figure 5.

LIBRARY

The usual services provided for Meteorological Service staff and for outside users of the Library were, as far as possible, maintained during 1988 and 1989.

Two further issues of the internal staff newsletter were produced (Nos 3 and 4, Spring and Summer 1988). This time the typesetting was done entirely on the newly acquired desktop publishing system, which permitted a much more attractive layout. A number of retired staff have expressed warm appreciation of the newsletter.

Close co-operation continued with librarians of other Government libraries. It is hoped that it will soon be possible, with the aid of IMAS (Department of Finance), to link all the major Government Libraries on a computer network. With this in mind, various commercially produced library housekeeping packages have been assessed in the hope of finding a good integrated system suitable for use on the network.

The Meteorological Service Library in-house system continues to work well. A major improvement has been the extension of the cataloguing program to allow real-time updating of the indexes. A description of the system has been published ('An in-house system for cataloguing, retrieval and loans in the Irish Meteorological Service Library') in Program: automated library and information systems, 22(4), October 1988, pp 337-353.

INSTRUMENTS AND EQUIPMENT

Anemometers

Repairs to the Dines anemometer at Birr were completed during 1988; most of the work had been carried out during 1987. Work carried out in 1988 included replacing the lead pipes from the ceiling to the float chamber and replacing the gunbarrel pipes through the roof. Minor adjustments had to be made to the float chamber in 1989 when the wind speed readings were found to be low.

The Dines anemometer at Claremorris was serviced in 1989 following a report that the float was probably leaking. The float was replaced with one that had been reconditioned in our own workshops.

At Dublin Airport the Dines anemometer suffered severe damage in 1989 when the mast was pulled down during grass cutting around the anemometer enclosure. Some work was done in replacing the anemometer but was not completed due to delays in getting spare parts from the supplier.

The Dansk Impulsphysik digital anemometers at Dublin and Shannon Airports operated very well during 1988 and 1989. However the Shannon system suffered minor damage due to electrical storms in the summer of 1988. There was no damage to the Dublin system largely due to the fact that a lightning protection unit, designed and built by the Instruments Division, had been installed in 1987. A similar protection unit sent to Shannon was installed in 1989. Components for repairs to the Impulsphysik systems are difficult to acquire and some are obsolete. However, because of the delays in installing the new Vaisala digital anemometers during 1988, work continued on repairing faulty printed circuit cards.

One of the new Vaisala digital anemometers was installed at Dublin Airport in 1988. Members of the Instruments staff attended a maintenance course given by a Vaisala representative following the installation. The mast for this anemometer was supplied by a local contractor. The displays for the system proved rather disappointing in that the yellow LEDs did not show up well in the tower positions especially during bright sunshine. This problem was investigated both by Vaisala and by the Instruments staff. In 1989 Vaisala agreed to replace all existing display units with an improved type.

Facsimile and Communications Network

The transmission and reception of facsimile charts and pictures over the dedicated data-line network was generally good during both years. Test charts continued to be sent on a regular basis and all faults were dealt with promptly.

In 1988, one of the Muirhead K-150-TR4 transmitters and one of the K-649-TR4 receivers was completely overhauled. One of the older D-649-L/E3 receivers from Casement was rebuilt in 1988. In 1989 another transmitter and receiver were also overhauled. Also in 1989 a K-949 digital facsimile receiver was despatched to Casement. The Spembly recorder which is used to receive satellite images was overhauled three times. This was necessary because this particular receiver is running almost continuously and requires more maintenance than other recorders. Two video copiers for use with the Technavia systems were purchased during 1988, one for CAFO and the other for Shannon Airport. This should relieve some of the burden placed on the Spembly recorder. A reconditioned recorder was bought from the BMO in 1988 and was installed in the meteorological office at RTE.

Two of the older D-649 series recorders which were in a poor condition were written off during 1988. However they were completely dismantled and all useful parts were kept as spares. It was decided that any more of the recorders from this series would be treated similarly in future.

Automatic Weather Stations (AWS)

The Agmet subgroup investigating automated climatological recording met on a regular basis during 1988 and a member of the Instruments Division was present at all these meetings. The Didcot climatological AWS which was bought in 1987 was erected on the roof of the HQ building and has undergone tests, with a view to installing it at Moore Park, Fermoy, Co. Cork in 1990. This station will be part of a national network with the Meteorological Service being the central database allowing all other users and subscribers access to the stored data. A considerable amount of time was spent in writing the software for the station's datalogger and for the transfer of the data to the mainframe computer. A second Didcot climatological AWS was bought in December 1988.

Ceilometers and Runway Visual Range (RVR)

Five Vaisala ceilometers were bought between 1988 and 1989. Two of these have been installed, one at Dublin Airport and the other at Cork Airport. The others are earmarked for Cork, Casement and Connaught Regional Airport (when the Service takes over meteorological operations there).

New Vaisala RVR system were installed at Dublin, Shannon and Cork Airports. The maintenance of the Dublin system is to be retained by the Meteorological Service, while the Shannon and Cork systems will be maintained by technical staff at both airports.

Other Activities

The Chessel multipoint digital recorder in Cork Airport was out of service for a considerable amount of time on two occasions in 1988 and 1989. The first of these was when the back-up program failed and the second occasion was when the main processor failed. On both occasions the manufacturers had to be called on to repair the recorder.

The cloud height searchlight at Kilkenny was replaced with a reconditioned until. The searchlight at Birr was rebuilt by a local contractor. A third unit has been reconditioned also and will replace an existing unit at one of the synoptic stations.

Mullingar was visited once in 1988 and four of the manometers used in the soil-moisture experiment were replaced as was most of the nylon tubing. There was another visit in 1989 when nine of the soil moisture blocks were replaced.

Routine preventative maintenance was carried out on a regular basis throughout both years. All faults were rectified quickly.

Quite a number of precision aneroid barometers were repaired and calibrated. Three more Vaisala digital Pa11 barometers were bought. The number of requests from outside agencies and members of the public for information on and specifications for meteorological instruments continued to increase.

Satellite Receiving Stations and Weather Surveillance Radar

Activities in these fields are reported on in the section on Observations

AGRICULTURAL METEOROLOGY

There is an increasing recognition among the agricultural community including farmers of the need for concern for the environment in everyday farm activity. The intensification of production with the higher use of nutrients and chemicals increases the risk of pollution of the wider environment. Sources of farm generated pollution include silage effluent, washdown water from farmyards, slurry, fertiliser run-off and leaching. Weather support services help the farmer to minimise the risks associated with all these sources.

Cooperation with Agricultural Bodies

Close cooperation continued with the main agricultural bodies, with the Department of Agriculture and Food and with the Faculties of Agriculture and related departments in the universities. During the two years, the Agrometeorological Bulletin was circulated to Researchers, Advisors and others. Following analysis of a questionnaire to recipients, the circulation was rationalised and reduced by 30%. Approximately 30% of recipients replied to the effect that they were willing to pay for the Bulletin. The overall presentaiton of the Bulletin was enhanced and additional material was included in the publication.

Animal Disease Control

Weather has both direct and indirect effects on animal health and on the survival and transmission of diseases. Cooperation with the Veterinary Authorities of the Department of Agriculture and Food helps to reduce the incidence of nematodiriasis in young lambs in spring and liver fluke in cattle and sheep in the autumn and winter. On the basis of the meteorological data and veterinary reports, the Department advises farmers on the risk of these diseases.

The Department is also anxious for the closest possible cooperation between it and the Meteorological Service in relation to Foot and Mouth Disease (F&M). With the advent of reduced EC interstate movement restrictions following 1992, the risk of the disease coming into Ireland will be increased. The acquisition of a model to predict the airborne spread of F&M following an outbreak in this country has been described in earlier Annual Reports. As the airborne virus can be deflected from its path by topographical features, a national terrain databank on a 1km grid was purchased by the Department of Agriculture and Food in 1988. This was assimilated into the programme.

Workshops on the role of wind and other elements in the spread of the disease were given at two Department training courses for veterinary officers at Nenagh and Mullingar in 1989. For the first time, officers were able to see a demonstration of the F&M model and how it supported the disease control operation. Great interest was displayed by the participants most of whom were previously unaware of the Meteorological Service's involvement.

International Cooperation

The phenology reports for the four phenological gardens were transmitted to the International Directorate of the Phenological Gardens' Programme in Germany.

Meteorological data for most of the Irish synoptic station were provided to the Joint Research Centre of the EC, Ispra, Italy in 1989 for the EC sponsored pilot project for remote sensing applied to agricultural statistics.

A number of questionnaires relating to the work of the Commission for Agricultural Meteorology (CAgM) were circulated to the relevant Research Centres and a synthesis of the replies returned to WMO.

Exhibition

The Meteorological Exhibition at the National Ploughing Championships was held in both years at Oak Park, Carlow supported by Teagasc and Telecom Eireann in 1988 and by the Farming Independent in 1989. Through the association with the Farming Independent, considerable publicity was given to the venture featuring the television team of weather forecasters and the publication of articles on weather and weather presentation. A central location at the Ploughing Championships was secured in

both years and attendance at the Meteorological Pavilion was very high over the three days.

Automatic Recording

Progress was made in the area of automatic climatological recording during the period. The Service purchased two stations in 1988 and programmes for interrogation, quality control and archiving of data were developed. This was necessary so that a national network of compatible systems could be established. One station compatible with the proposed automatic climatological network was purchased by Bord na Mona in 1989. This is to be installed early in 1990 at a site on Mount Dillon bog, Lanesboro, Co Longford as soon as a licence is granted for radio transmission facilities to the local office. The Meteorological Service is installing another station at the Teagasc Research Station, Moorepark, Fermoy, Co Cork while the Teagasc personnel at Johnstown Castle station, Co Wexford are investigating the purchase of another.

AGMET Group

Further progress was made during 1988/89 to advance the script of the handbook to be used by course teachers and students of the Certificate in Farming course. This Course is undertaken by all young people entering farming.

The Group met RTE Presentation to help in formulating the new graphics for the display of agricultural-weather related topics such as grass growth rates, soil moisture deficits and disease indices on the weekly TV farming forecast. The AGMET Group has also set up 'feedback' mechanisms with the farmer organisation to evaluate the service.

Other areas with which the Group are concerned, relate to quality of food and agricultural produce,and environmental pollution, and how they interact with weather.

The AGMET group organised a one-day conference and exhibition at University College, Dublin on February 29, 1988. The conference featured international speakers and attracted a large attendance.

MARINE METEOROLOGY

Apart from having overall responsibility for the making and collection of weather observations from Irish ships and from lighthouses and buoys near the Irish coasts (see section on Observations), the Marine Meteorology Unit provides research support to CAFO for the supply of special forecasts to marine interests (see section on Weather Forecasts). Also, this Unit is involved in the study of climatic conditions in Irish coastal waters, in the supply of marine climatological information and in the international aspects of marine meteorology. Wind and temperature measurements from the Marathon Gas Platform are quality controlled and archived within this Unit. All wind data from the Marathon Platform since measurements began in 1979 have now been put into computer-compatible format and analysis of these data is ongoing.

The computer archive of Irish marine climatological data, which is based on one million weather reports made in Irish waters by ships of many nationalities over the past 100 years, was used frequently in the preparation of replies to enquiries. Summaries were prepared of a numerical wave model output for 7 grid-points in the Celtic Sea and the Atlantic Ocean.

An analysis was carried out on the visual observations of wind, made since 1945, at 5 lightvessels. These data are the primary source of information on the interannual variation of the Irish offshore wind regime.

Waves at specific locations often depend critically on local conditions. An individual scheme which takes these into account and yet is straightforward to use, was developed in the Marine Unit for each site as required for the dedicated forecasts issued by CAFO.

Hindcasts of conditions at specific locations at sea or at the coast were prepared on request for investigations into accidents, legal disputes, insurance claims etc. Various requests were dealt with for information on the Irish marine climate and wind energy potential. Requests for both climatological and realtime information on sea temperatures became more numerous.

The E.C. Wind Energy Atlas Project, in which Ireland played an active role, ended in 1989 with the publication of the "European Wind Atlas".

ADMINISTRATION

Government restrictions on recruitment, promotions and payable overtime continued to cause serious difficulties in many areas of the Service. The report of the Review Group, which was established in February 1986 to examine the structure of the Service and to advise on staffing and equipment requirements, was the basis for ongoing discussions between the Service, the parent Department (Tourism and Transport) and staff interests. The Review recommended various changes in staffing levels with an overall complement of 260. The total number of full-time staff was 300 on 31 December 1986 and 287 on 31 December 1987.

Staff Numbers

Staff members serving on 31 December 1988 and 31 December 1989 (in brackets) were as follows :

Director	0 (1)
Assistant Director	1 (1)
Senior Meteorologist	8 (6)
Meteorologist	37 (38)
Principal Meteorological Officer	4 (3)
Senior Meteorological Officer	27 (27)
Meteorological Officer	124 (123)
Assistant Meteorological Officer	30 (30)
Other grades	27 (24)
TOTAL (full-time)	258 (253)
Part-time staff	12 (13)
OVERALL TOTAL	268 (265)

A total of 9 staff members were on career breaks at the end of 1988 and 7 personnel were on such breaks at the end of 1989.

Retirements

There were 27 retirements in 1988 (many of them under the Public Service early retirement scheme), 1 resignation and 1 staff member was transferred to another Department on promotion. In 1989 there were 3 retirements and 2 resignations.

Maurice Fitzgerald, Meteorological Officer retired on 21 January 1988, Patrick Shine, Technical Assistant, on 29 February; Sean O'Regan, Meteorological Officer on 1 May; Patrick Roberts, Senior Meteorological Officer on 7 May; Sean McAuliffe, Senior Meteorological Officer on 30 June; Thomas Horgan, Meteorological Officer, on 1 July; Patrick Cotter, Assistant Meteorological Officer on 4 August; Desmond Cooney, Meteorological Officer on 1 September; Alan Nolan, Owen Hearty, Patrick Stafford and William Turner, Meteorological Officers and James Hughes, Messenger on 1 October; Michael Connaughton, Meteorologist on 4 October; Donal Linehan, Director on 6 November; Cormac O'Connor, Senior Meteorologist, Dominic Finn and Francis Fitzgerald, Meteorologists and Finbar Murphy, Senior Meteorological Officer on 1 December; Kevin Murphy, Meteorologist, Philip Ryan, Principal Meteorological Officer, Patrick Flynn and John Meere, Senior Meteorological Officers,Liam Kirby, Hugh O'Regan, John Scanlan and Oliver Veale, Meteorological Officers on 14 December.

Patrick Cronin, Technical Officer retired on 9 February 1989; Patrick Kelly, Principal Meteorological Officer, on 15 September and George Callaghan, Senior Meteorologist on 26 September.

Obituaries

We regret to record the deaths of two staff members during 1988. John Moynihan, Meteorological Officer died on 8 February at the age of 57. John joined the Service in 1950 and served at Cork Airport for most of his career. He also served at Midleton, Dublin and Shannon Airports, and at Valentia Observatory prior to the opening of the Cork Office in 1961.

Florence (Flos) O'Shea, Handyman, died suddenly on 17 March, aged 59. Flos was a native of Cahirciveen, Co Kerry and worked at the local Valentia Observatory since 1980. Although employed in the Service for only a relatively short time he was highly regarded by his Observatory colleagues for his diligence and genial nature.

Patrick Roberts, who had retired in May 1988, died on 28 January 1989 aged 54. Paddy had not enjoyed the best of health for some years. He joined the Service in 1953 and served in Dublin and Shannon Airports, Valentia Observatory, Casement Aerodrome and Headquarters.

We also learned, with regret, of the death on 4 September 1988 of Frederick Dixon. Fred joined the Service in 1939. He served at Foynes, Shannon Airport, Dublin Airport and Headquarters and was promoted to Senior Meteorologist in 1956 when he assumed duty as Officer-in-Charge of the newly-established, combined Training School and synoptic station at Rosslare Harbour. He returned to Dublin in 1962 and was in charge of Dublin Airport (1963-64); the Central Analysis and Forecast Office (1964-1975) and the Climatological Division from 1975 until his retirement in March 1977.

INTERNATIONAL COOPERATION

The Meteorological Service continued its active involvement in international meteorology during 1988 and 1989 and participated in projects and meetings of the various international and regional meteorological bodies.

World Meteorological Organization (WMO)

Dr J Hamilton attended a Technical Conference on Operational Forecasting in Geneva; Mr K Commins attended TECO-88 in Leipzig and Mr P A Lyons attended a CAeM Working Group on the 'Provision of Meteorological Information required before and during Flight" in Geneva. In 1989 a selection of meetings attended was as follows :- Mr L Burke attended the 10th session of the Commission of Marine Meteorology in Paris; Mr E Murphy attended the 10th session of the Commission for Instruments and Methods of Observation in Brussels; Mr D Fitzgerald attended a session of the Commission for Climatology in Lisbon and Mr P A Lyons attended a meeting of an expert group on Aeronautical Meteorology Codes in Geneva.

International Civil Aviation Organization (ICAO)

Mr P A Lyons attended a meeting of the Meteorological Advisory Group (METAG) of the European Air Navigation Planning Group (EANPG) of ICAO in Paris - October 1988 and a further meeting of METAG, also in Paris, in March 1989.

European Centre for Medium Range Weather Forecasts (ECMWF)

The Director represented Ireland at meetings of the ECMWF Council. Mr W H Wann, Assistant Director attended meetings of the Council and a meeting of the Technical Advisory Committee (TAC). Mr B McWilliams, Chairman of the Finance Committee, attended meetings of that Committee and of the Council and also a meeting of the TAC. Messrs P Halton, D J Murphy and Dr Hamilton attended technical meetings dealing with computers and network security.

European Cooperation in Science and Technology (COST projects)

The Service was represented at a COST 43 meeting in Madrid by Mr W G Callaghan and in Brussels by Mr L Burke. Mr L Keegan attended a meeting of the COST 73 Management Committee in Brussels. During 1989 COST meetings in Paris and Brussels were attended by Mr Wann and Mr G McDonald respectively.

European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)

Meetings of the EUMETSAT Council were attended by the Director or the Assistant Director. Mr B McWilliams also attended meetings of the Council and of EUMETSAT groups dealing with financial and other aspects.

Meetings of Directors of Western European Meteorological Services

The Director attended the annual meeting of Directors of Western European Meteorological Services held in Brussels in 1988. Dublin was the venue for the 1989 meeting which was hosted by Mr W H Wann, Assistant Director, as the post of Director of the Meteorological Service had not yet been filled following the retirement of Mr D Linehan the previous November.

European Group on Ocean Stations (EGOS)

Ireland participated in a project dealing with deployment of drifting and moored meteorological buoys, both in the eastern North Atlantic Ocean. This project was under the auspices of the EC as COST 43 but, in December 1988, responsibility was taken over by the newly-formed European Group on Ocean Stations (EGOS). Mr L Burke, who attended the December 1988 meeting in Paris and the June 1989 meetings of the

Management Committee and the Technical Subgroup of EGOS (which were hosted by the Meteorological Service in Dublin) was elected chairman of the Management Committee at the December 1989 meeting in Paris.

North Atlantic Ocean Stations Agreement (NAOS)

Participation continued in the NAOS Agreement for the maintenance of ocean weather ships until November 1988 when this Agreement ended. Mr W G Callaghan attended a meeting of the NAOS Board held in Geneva in August 1988.

High Resolution Limited Area Modelling (HIRLAM)

This is a cooperative research venture which includes participants from Denmark, Finland, Holland, Norway, Sweden and Ireland. Ireland joined this group in April 1989. Phase II of this cooperation covers the three year period 1989-1991. The goal of the effort is the production of a fine mesh model with sophisticated physics, capable of providing detailed and accurate short range forecasts. This model will form the kernal of our future operational numerical prediction system. Dr P Lynch attended HIRLAM meetings in Norrkoping and Oslo.

Other International Meetings

Mr D Murphy, Director, was present as an observer at the Commonwealth Meteorological Conference held in Reading in June 1989. Dr J Hamilton attended the 4th International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography and Hydrology in Anaheim, California. Dr P Lynch attended the 1988 European Geophysical Society General Assembly in Bologna and the 1989 Assembly in Barcelona. He also attended the 5th Scientific Assembly of IAMAP in Reading and meetings of the European Working Group on Limited Area Modelling held in Helsinki and Rome.

STAFF TRAINING

Four overseas students (from Afghanistan, Lesotho, Sudan and Uganda) completed the 10-month Class I Meteorologists Course in July 1988. This course was based in Galway but included periods of practical training in Shannon Airport and Headquarters. A further group of three students, from Iran, Malawi and Tanzania, was trained between October 1988 and July 1989. This was the last training course for foreign students as it was decided to terminate the scheme in 1989, mainly because the necessary training staff could no longer be spared. The Officer-in-Charge of the Training Division was transferred to Headquarters in September 1989. In all, 13 foreign students from 10 countries completed the Class 1 Meteorologists Course between 1985 and 1989, all but one of them successfully.

There was no recruitment to the Service during 1988 or 1989. However, one officer who was promoted from Meteorological Officer to Meteorologist was trained along with the last group of overseas students. Another promoted Meteorological Officer commenced the meteorologist training course in Headquarters in November 1989.

APPENDIX 1

PUBLICATIONS DURING 1988 and 1989

(a) Meteorological Service Publications

1. Technical Note No 51 "The Estimation of Extreme Wind Speeds over Standard Terrain in Ireland" by J.J. Logue
2. Monthly Weather Report Part I, January 1987 to August 1988 and the 1987 Annual Summary
3. Monthly Weather Bulletin January 1988 to November 1989
4. Solar Radiation Observations 1986, 1987 and 1988
5. Magnetic Observations at Valentia Observatory 1986, 1987 and 1988
6. Agricultural Meteorological Bulletin January 1988 to November 1989
7. Internal Memorandum 111/88 "Analysis and Prediction of Air Pollution in the Dublin Area" by R. McGrath
8. Internal Memorandum 112/89 "Trajectory Models and their use in the Irish Meteorological Service" by R. McGrath

(b) Other Publications

1. "An In-house System for Cataloguing, Retrieval and Loans in the Irish Meteorological Service Library" by Lisa Shields in Program: Automated Library and Information Systems, 22(4) October 1988
2. "Charts: an Interactive Graphics System for the Display of Meteorological Fields used at the Irish Meteorological Service" by J.E.M. Hamilton, Proceedings of a Workshop on Meteorological Operations Systems (December 1987) Published April 1988.
3. "Deducing the Wind from the Vorticity and Divergence" by P. Lynch, Mon. Weather Review 116 86-93
4. "Deduction of Analysis Structure Functions from Variational Principles" by P. Lynch, EWGLAM Newsletter No 18
5. "The Slow Equations" by P. Lynch, Q.J. Roy. Met. Soc. 114 201-219
6. "Semi-Lagrangian Integration of a Gridpoint Shallow Water Model on the Sphere" by A. McDonald and J.R. Bates, Mon. Weather Review 117 130-137
7. "Partitioning the Wind in a Limited Domain" by P. Lynch, Mon. Weather Review 117 1492-1500
8. "The 'Night of the Big Wind' in Ireland, 6-7 January, 1939", by Lisa Shields and D. Fitzgerald, Irish Geography Vol 22 Part I 1989 31-43

APPENDIX 2

A SELECTION OF LECTURES GIVEN BY STAFF DURING 1988 and 1989

1988

1. "Irish Traditional Weather Lore" by Lisa Shields to the Folklore and Folkmusic Society of Clare, at Spanish Point.

2. "Weather for Outdoor Pursuits" by L. Campbell at seminar held at Little Killary Adventure Centre, Galway.

3. "Wind and Wave Energy; The Availability of the Resource" by L. Burke to Joint Meeting of Solar Energy Society of Ireland and the Irish Meteorological Society in Galway.

4. "The Use of Computer Graphics in Weather Services" by J.E.M. Hamilton at the Technical Conference on Operational Weather Forecasting, Geneva.

5. "Computing Tomorrow's Weather" by P. Lynch to Maths Physics Dept., University College, Dublin.

6. "Meteorology for Sailing" by P. MacHugh to Glenans Sailing Club.

7. "Some Features of the Irish Climate Relevant to Plant Pathology" by T. Keane to Society of Irish Plant Pathologists.

1989

1. "Aviation Meteorology" by P. J. Connolly to Aer Rianta study group in Airport Management at Bunratty.

2. "Use of Computerised Meteorological Data in Horticulture" by T. Keane to the Institute of Horticulture Seminar on Information Technology for Horticulture. University College Dublin.

3. "Meteorology and Architecture" by D. Fitzgerald to students at University College, Dublin.

4. "Integration Schemes using Laplace and Z Transforms" by P. Lynch to European Geophysical Society, Barcelona.

APPENDIX 3

SPECIAL TOPICS IN PREVIOUS ANNUAL REPORTS

1975	Development of the Meteorological Service
1976	Valentia Observatory
1977	Our Voluntary Observers
1978	The Meteorological Office at Foynes
1979	The New Headquarters Building
1980	The Use of Computers in the Meteorological Service
1981	The Use of Satellites in the Meteorological Service
1982	Telecommunications in the Meteorological Service
1983	The World Climate Programme
1984	The Central Analysis and Forecast Office
1985	The Meteorological Service - The First 50 Years
1986	Usefulness of Weather Forecasts
1987	Computer Weather Forecasting